

WHAT IS CLAIMED IS

1. A reflecting micro-optical component comprising:
  - a. a material transparent to light of a predetermined wavelength;and
  - b. an envelope for bounding said material, said envelope including a curved section and at least two non-parallel flat sections, said curved section operative to perform total internal reflection of light entering said component through its one said flat section, thereby directing said reflected light to leave said component through its other said flat section,whereby said reflecting micro-optical component can reflect and couple light from one optical element into another optical element.
2. The reflecting micro-optical component of claim 1, wherein said material is a photoresist, whereby said reflecting micro-optical component is a photoresist microlens.
3. The reflecting micro-optical component of claim 1, wherein said material is a glass, whereby said reflecting micro-optical component is a glass microlens.
4. The reflecting micro-optical component of claim 1, further comprising a thin reflecting layer covering said curved section.
5. The reflecting micro-optical component of claim 1, wherein said reflecting layer is a metal.
6. The reflecting micro-optical component of claim 1, wherein said curved section is semispherical.
7. The reflecting micro-optical component of claim 1, wherein said two non-parallel flat sections are orthogonal to each other.

8. The reflecting micro-optical component of claim 1, wherein said one optical element is a waveguide positioned on a substrate, and wherein said another optical element is a detector formed in said substrate.

9. The reflecting micro-optical component of claim 1, wherein said substrate is silicon.

10. The reflecting micro-optical component of claim 1, wherein said one optical element is a waveguide positioned horizontally on a substrate, and wherein said another optical element is a vertically emitting light source formed in said substrate.

11. The reflecting micro-optical component of claim 1, wherein said one optical element is a waveguide positioned horizontally on a substrate, and wherein said another optical element is a light fiber positioned to emit light vertically through a section of said substrate.

12. A reflecting micro-optical component comprising:

- a. a curved envelope section separating a light transparent material from a first external medium;
- b. a first flat envelope section separating said material from a second external medium; and
- c. a second flat envelope section positioned substantially vertical to said first flat section and separating said material from a third external medium;

whereby light entering said component from said second external medium is totally internally reflected from said curved section into said third external medium.

13. The reflecting micro-optical component of claim 12, wherein said material is a photoresist, whereby said reflecting micro-optical component is a photoresist microlens.

14. The reflecting micro-optical component of claim 12, wherein said material is a glass, whereby said reflecting micro-optical component is a glass microlens..

15. The reflecting micro-optical component of claim 12, further comprising a thin reflecting layer covering said curved envelope section.

16. The reflecting micro-optical component of claim 15, wherein said reflecting layer is a metal.

17. The reflecting micro-optical component of claim 12, wherein said second external medium is a waveguiding medium and wherein said third external medium is a photodetecting medium.

18. The reflecting micro-optical component of claim 12, wherein said second external medium is a light emitting medium and wherein said third external medium is a waveguiding medium.

19. The reflecting micro-optical component of claim 12, wherein said second external medium is light carrying optical fiber and wherein said third external medium is a waveguiding medium.

20. The reflecting micro-optical component of claim 17, integrated on a substrate that includes said photodetecting medium and supports said waveguiding medium.

21. The reflecting micro-optical component of claim 20, wherein said substrate is silicon.

22. The reflecting micro-optical component of claim 18, wherein said light emitting medium is a vertically emitting light source.

23. The reflecting micro-optical component of claim 12, integrated on a substrate that includes said vertically emitting light source and supports said waveguiding medium.

24. A microreflector comprising:

a. an element made of a material transparent to light of a predetermined wavelength and operative to couple optically to one micro-optical component through a first flat surface and to another micro-optical component through a second flat surface; and

b. a curved envelope section defining a reflective surface of said element, whereby light originating from one of said micro-optical components is reflected internally by said curved envelope section into the other of said micro-optical components.

25. The microreflector of claim 24, further comprising a thin reflective layer formed on said curved envelope externally to said material, whereby said reflective layer further enhances said coupling.

26. The microreflector of claim 25, wherein said thin reflecting layer is a reflecting non-metal layer.

27. The microreflector of claim 24, wherein said micro-optical components include a waveguide and a photodetector.

28. The microreflector of claim 24, wherein said micro-optical components include a waveguide and a light emitting source.

29. The microreflector of claim 24, integrated on the same substrate with said micro-optical components.

30. A method of coupling light between two micro-optical components, comprising the steps of:

a. forming a microlens reflector operative to reflect light from a first of the two micro-optical components to the second of the two micro-optical components; and

b. coupling light from said first to said second micro-optical component, wherein said light is at least partially reflected internally in said microlens reflector on its path from said first to said second micro-optical component.

31. The method of claim 30, wherein said step of forming a microlens includes forming a photoresist microlens having a curved external surface.

32. The method of claim 31, wherein said step of forming further includes forming a thin reflecting layer over said external surface.

33. The method of claim 30, wherein said first micro-optical component is a waveguide, wherein said second micro-optical component is a photodetector, and wherein said step of coupling includes reflecting light from said waveguide into said photodetector.

34. The method of claim 30, wherein said first micro-optical component is a light emitting source, wherein said second micro-optical component is a waveguide, and wherein said step of coupling includes reflecting light from said light emitting source into said waveguide.

35. The method of claim 30, wherein said first micro-optical component is an optical fiber, wherein said second micro-optical component is a waveguide, and wherein said step of coupling includes reflecting light from said optical fiber into said waveguide.

36. A three-dimensional (3D) optical interconnection architecture comprising:

- a. a substrate; and
- b. a NxM array of microlens reflectors formed on said substrate and operative to optically couple an array of N optical fibers to M optical waveguides.

37. The 3D architecture of claim 36, wherein said optical coupling includes a  $90^{\circ}$  out-of-plane coupling scheme.

38. The 3D architecture of claim 37, wherein said waveguides are formed on and in parallel with a front surface of said substrate and wherein said optical fibers are positioned to emit and receive light through said substrate perpendicular to said front surface, whereby said emitted and received light is reflected by said microlenses.

39. The 3D architecture of claim 38, wherein said positioning of said optical fibers is enabled by vertical holes formed from a back surface of said substrate.

40. The 3D architecture of claim 39, wherein said substrate is a silicon wafer, wherein said front surface is an oxidized surface having an oxide layer, wherein said holes are formed by etching said silicon substrate from said back surface to said oxide layer, and wherein said optical fibers are positioned inside said holes in close proximity to said oxide layer.

41. A 3 dimensional (3D) optical input/output architecture comprising:

- a. a substrate; and
- b. an array of reflecting micro-optical components formed on said substrate and operative to couple light between a first plurality of N optical components and a second plurality of M optical components, each said reflecting micro-component further comprising:
  - i. a material transparent to light of a predetermined wavelength;and
  - ii. an envelope for bounding said material, said envelope comprising a curved section and at least two non-parallel flat sections, said curved section operative to reflect internally light entering said component through one said flat section, said reflected light directed to leave said component through its other said flat section,

whereby said architecture enables 3D light coupling from said first plurality of N optical components to said second plurality of M optical components and from said second plurality of M optical components to said first plurality of N optical components.

42. The 3D optical input/output architecture of claim 41, wherein said material is a photoresist.

43. The 3D optical input/output architecture of claim 41, wherein material is a glass.

44. The 3D optical input/output architecture of claim 41, wherein each said reflecting micro-optical component further comprises a thin reflecting layer covering said curved section.

45. The 3D optical input/output architecture of claim 41, wherein each said curved section is semispherical.

46. The 3D optical input/output architecture of claim 41, wherein said two non-parallel flat sections are orthogonal to each other.

47. The 3D optical input/output architecture of claim 46, wherein said first plurality of N optical components includes N optical fibers positioned through said substrate in perpendicular to a top surface of said substrate, and wherein said second plurality of M optical components includes M waveguides positioned in parallel with and substantially on said substrate surface.

48. The 3D optical input/output architecture of claim 47, wherein said substrate is a silicon substrate.

49. The 3D optical input/output architecture of claim 41, wherein  $M=N$ .

50. The 3D optical input/output architecture of claim 41, implemented in a  $M \times N$  optical cross connect.